



# Fermi

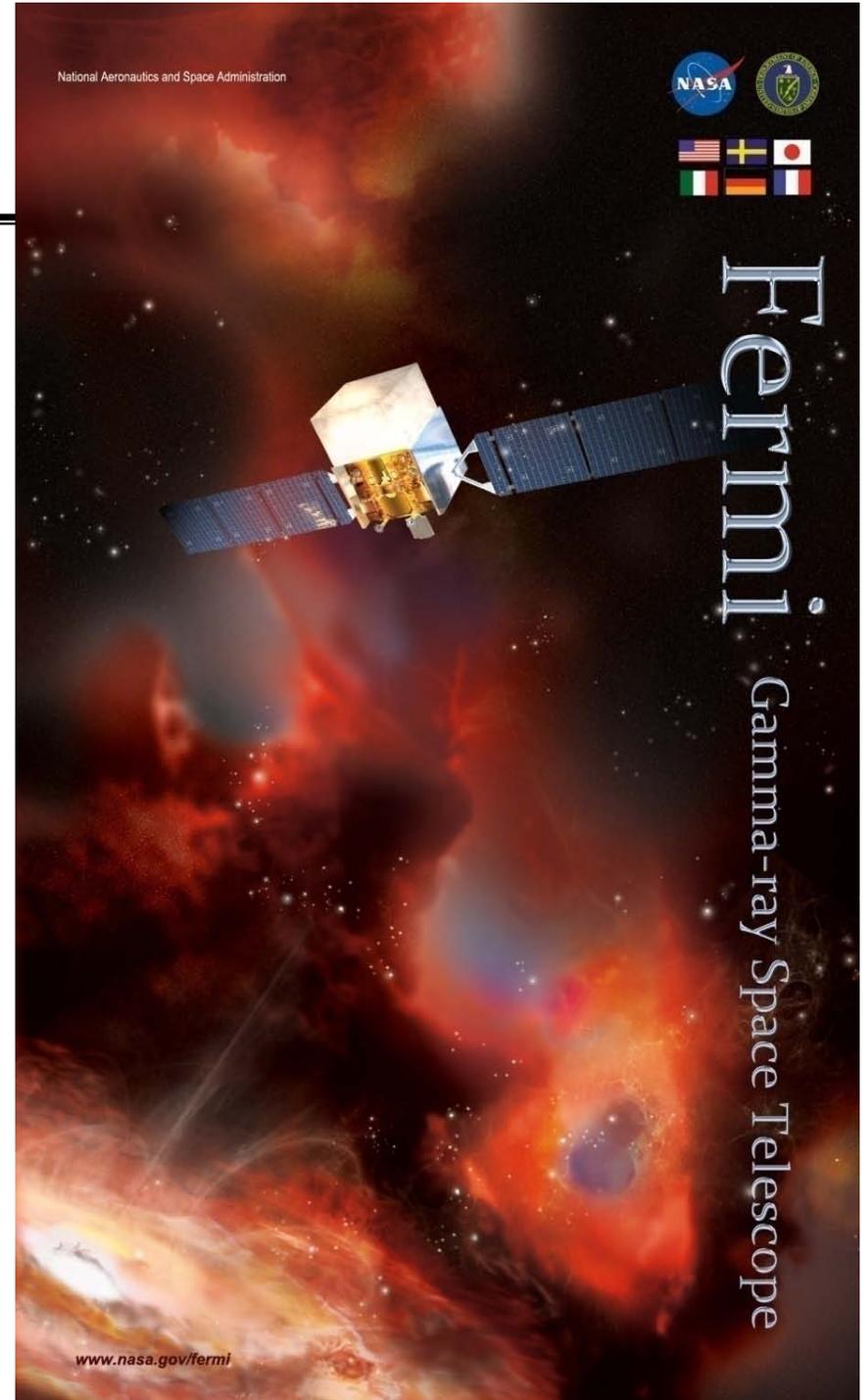
The Gamma-ray Large Area Space Telescope

## Mission Status

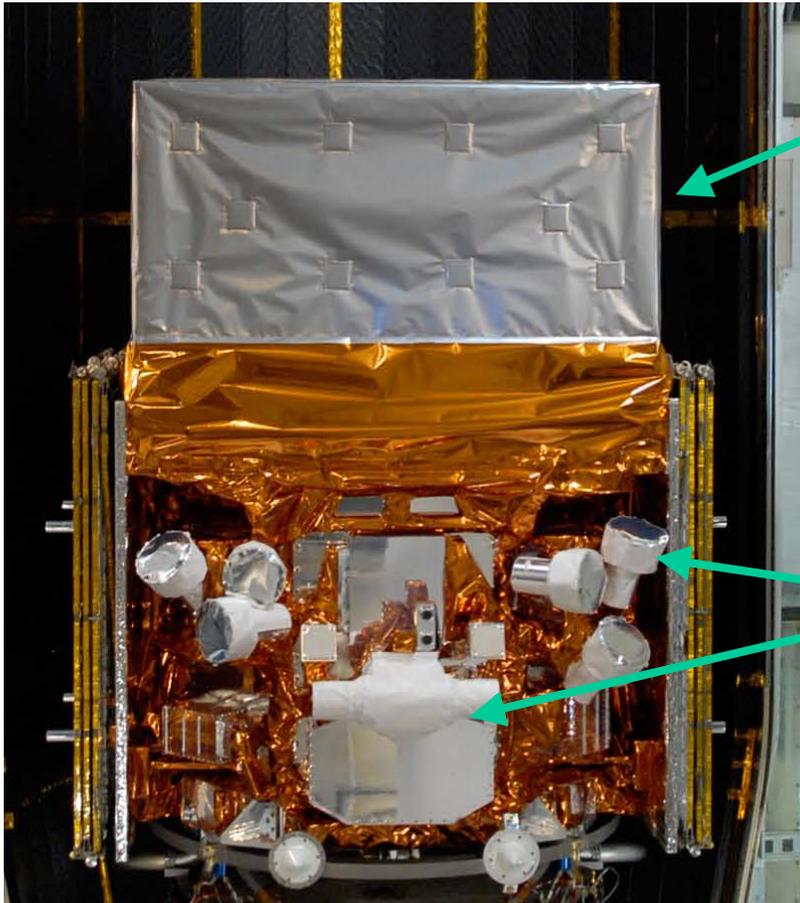
Liz Hays

On behalf of the Fermi Mission Team

<http://fermi.gsfc.nasa.gov>



# Fermi Instruments



## Large Area Telescope (LAT):

- 20 MeV - >300 GeV (including unexplored region 10-100 GeV)
- 2.4 sr FoV (scans entire sky every ~3hrs)

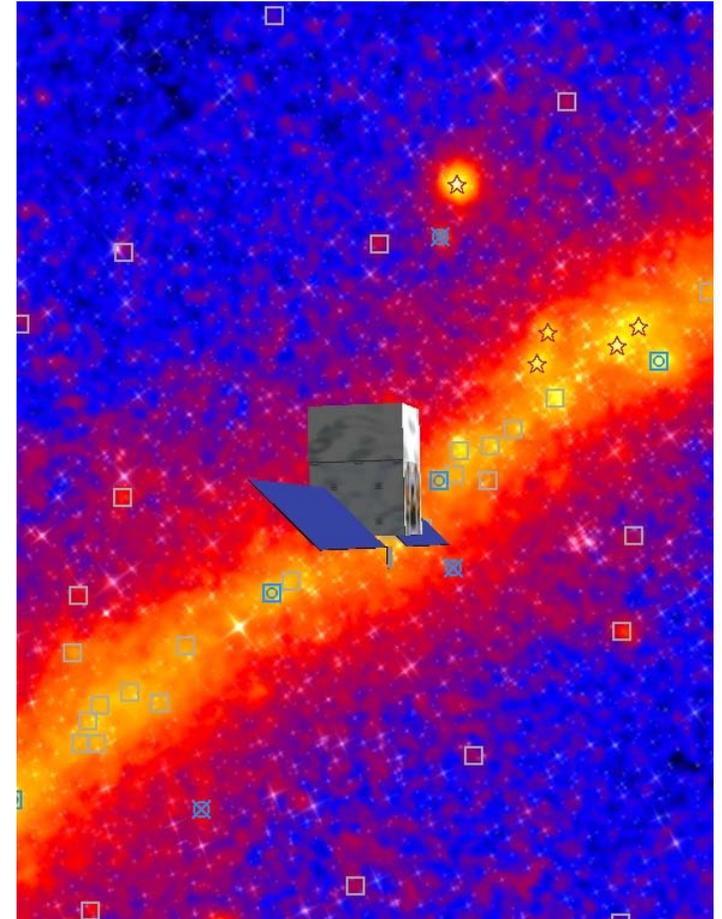
## Gamma-ray Burst Monitor (GBM)

- 8 keV - 40 MeV
- views entire unocculted sky

- **Large leap in all key capabilities, transforming our knowledge of the gamma-ray universe. Great discovery potential.**

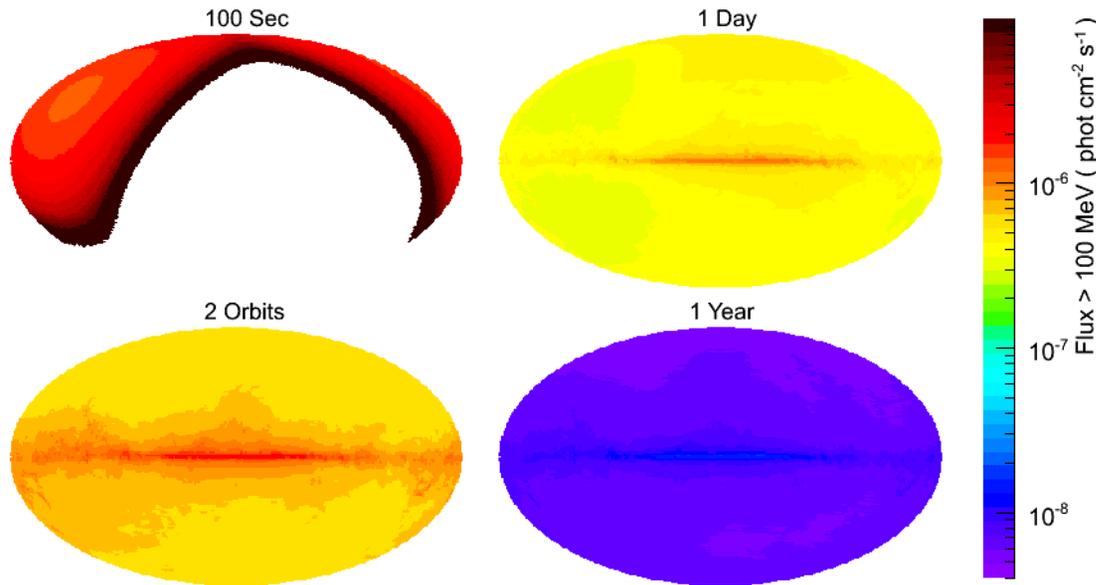
# Observatory Highlights

- **Launched from Cape Canaveral Air Station 11 June 2008 at 12:05PM EDT**
- **Science operations since August 2008**
- **First Light - Renamed for Enrico Fermi**
- **>1000 days on orbit**
- **>16000 orbits completed**
- **Orbit altitude has only decayed by 1.2 km since launch**
- **Practically no data loss (>99.99% retrieved from the spacecraft over entire mission)**



**Operations have been extremely smooth throughout the mission thanks to our very dedicated observatory and instrument operations teams!**

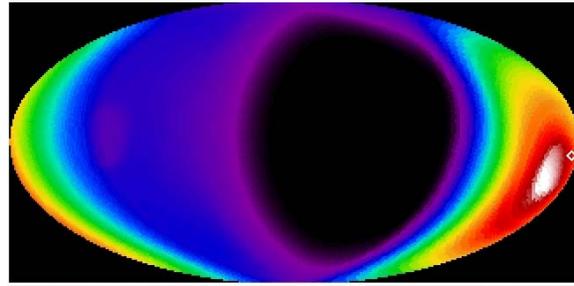
# Standard Observing



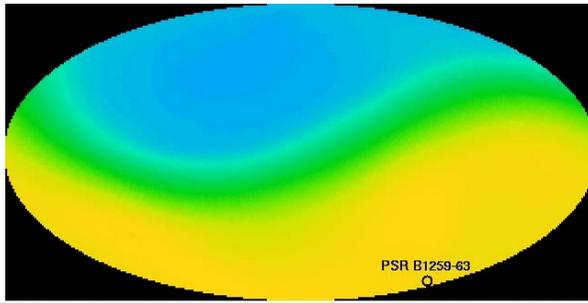
**LAT sensitivity on 4 different timescales: 100 s, 2 orbits (2x96 min), 1 day and 1 year**

- **Almost all observations in survey mode since last symposium**
  - **50 deg rocking angle exclusively after 2009 May 27**
  - **Slewing rate adjusted to slow the transition and lower peak wheel speeds on 2010 Sept. 16**
- **Autonomous Repoint Requests (ARRs)**
  - **1-2 per month**
  - **Duration reduced from 5 hr to 2.5 hr**
- **LAT Calibrations (<14 hours)**

# Non-standard Observing



0 0.5 1 1.5 2 2.5 3 3.5 4 4.5



0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8

**Target of Opportunity:** Pointed mode observations that can be triggered quickly (<24 hrs)

**Modified Survey:** Survey profile with reduced slews slightly enhances exposure in Northern or Southern Hemisphere

- 4 TOOs
  - 3C 454.3 (200 ks), Crab I (360 ks), Cyg X-3 (500 ks), Crab II (630 ks; see talks by R. Buehler and C. Wilson-Hodge)
- 1 modified survey mode observation
  - 2 orbits south, 1 orbit north to enhance coverage during PSR B1259 periastron passage (see talk by A. Abdo)



# Benefits of Planning

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- **Investigators at any institution can submit requests for observations through the GI program**
  - **TOOs accepted to the GI program are pre-approved**
- **Predictable events can be planned to reduce impacts on sky coverage**
- **Consultation with the mission team can provide advice on the best mode for your observation**

# Observation Record at FSSC



**GODDARD  
SPACE FLIGHT CENTER**

+ NASA Homepage  
+ GSFC Homepage  
+ Fermi Homepage

SEARCH Fermi:

+ GO

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HOME
OBSERVATIONS
DATA
PROPOSALS
LIBRARY
HEASARC
HELP
SITE MAP

+ FSSC Home

**Observations**

Observatory Status

Observing Timeline

+ Timeline Posting  
+ As-Flown vs. Planned  
Timeline Reconciliation

Observatory Status

Observing Timeline

+ Timeline Posting  
+ As-Flown vs. Planned  
Timeline Reconciliation  
+ Target-of-Opportunity  
Status

+ Predicted Pointing (FT2)

Observation Types

Multiwavelength  
Observations

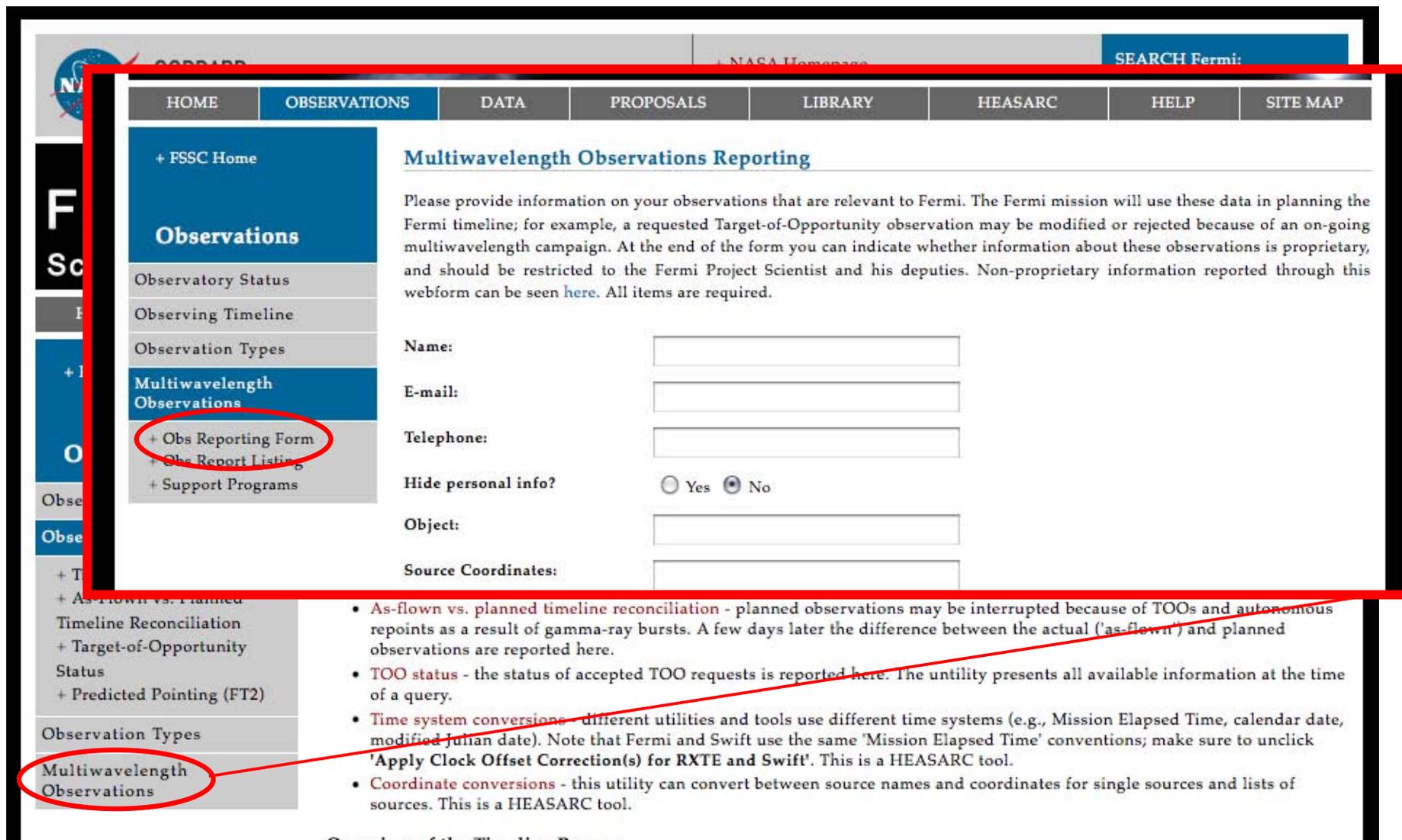
## Fermi Approved Targets-of-Opportunity

| Observation Number | Approximate ToO Time (UTC) | Principal Investigator | Target Name | RA (J2000) | Dec (J2000) | Observation Mode | Planned Duration (ks) |
|--------------------|----------------------------|------------------------|-------------|------------|-------------|------------------|-----------------------|
| 030604-1-1         | 2011-04-12 15:49:43        | DR. ELIZABETH HAYS     | CRAB        | 83.6330    | 12.0140     | NOMINAL          | 300.00                |
| 030603-1-1         | 2011-03-24 15:32:58        | PROF. STEPHANE CORBEL  | CYG X-3     | 308.1100   | 30.9800     | NOMINAL          | 500.00                |
| 030602-1-1         | 2010-12-23 19:37:42        | DR. AOUS ABDO          | PSRB1259-63 | 195.6980   | -63.8360    | NOMINAL          | 1200.00               |
| 030600-1-1         | 2010-09-23 15:49:00        | DR. ELIZABETH HAYS     | CRAB NEBULA | 83.6330    | 12.0140     | NOMINAL          | 500.00                |
| 020602-1-1         | 0000-00-00 00:00:00        | DR. JULIE E MCENERY    | 3C 454.3    | 343.4910   | 26.1480     | NOMINAL          | 200.00                |

The following are utilities that provide you with these capabilities:

- Timeline posting - through this webpage you can determine Fermi's pointing history in the past, and find future observing plans. The most accurate observing information available is used.
- As-flown vs. planned timeline reconciliation - planned observations may be interrupted because of TOO's and autonomous repoints as a result of gamma-ray bursts. A few days later the difference between the actual ('as-flown') and planned observations are reported here.
- TOO status** - the status of accepted TOO requests is reported here. The utility presents all available information at the time of a query.
- Time system conversions - different utilities and tools use different time systems (e.g., Mission Elapsed Time, calendar date, modified Julian date). Note that Fermi and Swift use the same 'Mission Elapsed Time' conventions; make sure to unclick 'Apply Clock Offset Correction(s) for RXTE and Swift'. This is a HEASARC tool.
- Coordinate conversions - this utility can convert between source names and coordinates for single sources and lists of sources. This is a HEASARC tool.

# Multiwavelength Reporting



The screenshot shows the 'Multiwavelength Observations Reporting' webform. A red box highlights the main content area, including the navigation menu, the form fields, and the introductory text. A red circle highlights the 'Multiwavelength Observations' link in the left sidebar and the 'Multiwavelength Observations' link in the bottom sidebar.

**Navigation Menu:** HOME, OBSERVATIONS, DATA, PROPOSALS, LIBRARY, HEASARC, HELP, SITE MAP

**Left Sidebar:** + FSSC Home, Observations, Observatory Status, Observing Timeline, Observation Types, Multiwavelength Observations, + Obs Reporting Form, + Obs Report Listing, + Support Programs

**Form Fields:** Name, E-mail, Telephone, Hide personal info? (Yes/No), Object, Source Coordinates

**Introductory Text:** Please provide information on your observations that are relevant to Fermi. The Fermi mission will use these data in planning the Fermi timeline; for example, a requested Target-of-Opportunity observation may be modified or rejected because of an on-going multiwavelength campaign. At the end of the form you can indicate whether information about these observations is proprietary, and should be restricted to the Fermi Project Scientist and his deputies. Non-proprietary information reported through this webform can be seen here. All items are required.

**Bottom Sidebar:** + Timeline Reconciliation, + As-flown vs. Planned Timeline Reconciliation, + Target-of-Opportunity Status, + Predicted Pointing (FT2), Observation Types, Multiwavelength Observations

**Bottom Text:**

- **As-flown vs. planned timeline reconciliation** - planned observations may be interrupted because of TOO's and autonomous repoints as a result of gamma-ray bursts. A few days later the difference between the actual ('as-flown') and planned observations are reported here.
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# LAT Collaboration

- **France**
  - CNRS/IN2P3, CEA/Saclay
- **Italy**
  - INFN, ASI, INAF
- **Japan**
  - Hiroshima University
  - ISAS/JAXA
  - RIKEN
  - Tokyo Institute of Technology
- **Sweden**
  - Royal Institute of Technology (KTH)
  - Stockholm University
- **United States**
  - Stanford University (SLAC and HEPL/Physics)
  - University of California, Santa Cruz - Santa Cruz Institute for Particle Physics
  - Goddard Space Flight Center
  - Naval Research Laboratory
  - Sonoma State University
  - The Ohio State University
  - University of Washington

**PI: Peter Michelson**

(Stanford)

~400 Scientific Members (including  
96 Affiliated Scientists, plus 68  
Postdocs and 105 Students)

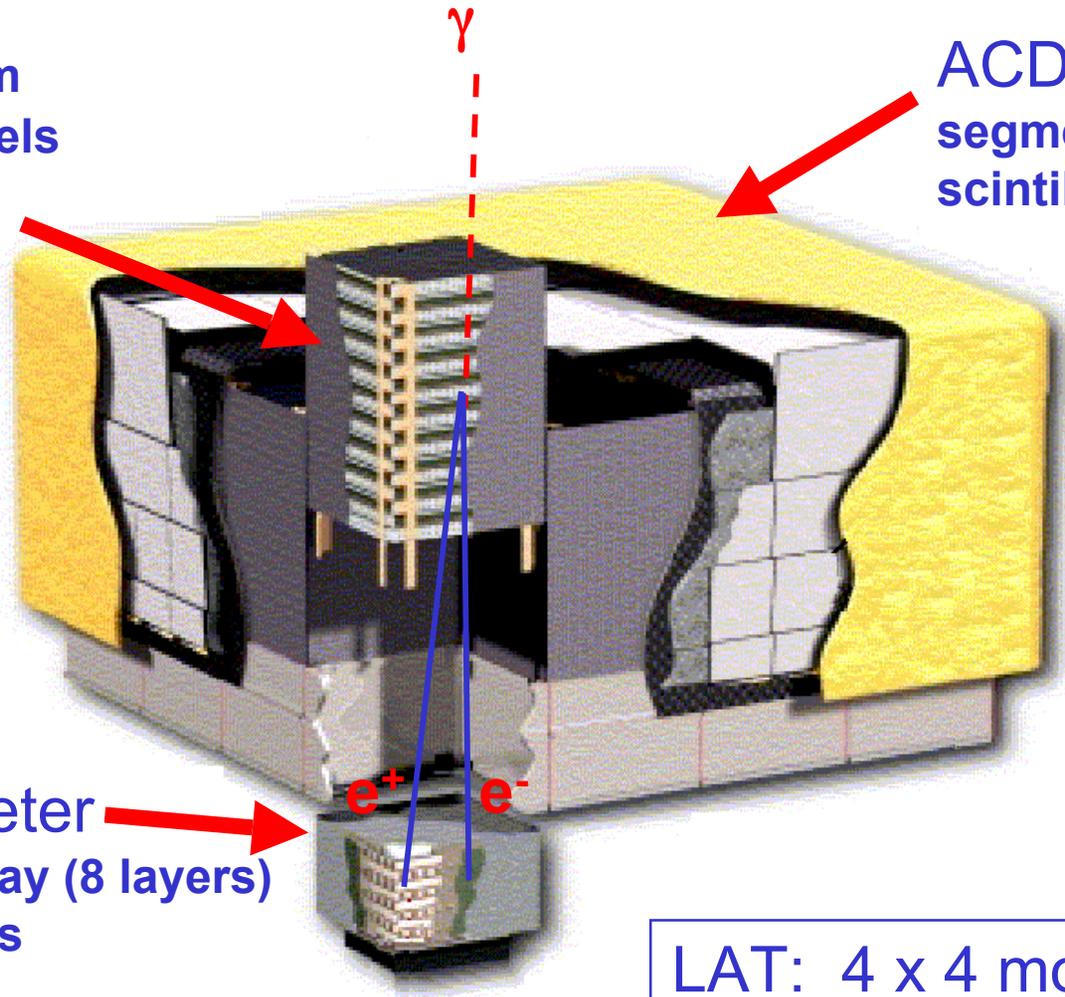
**Cooperation between NASA  
and DOE, with key  
international contributions  
from France, Italy, Japan and  
Sweden.**

**Project managed at SLAC.**

# The Large Area Telescope

**Si Tracker**  
pitch = 228  $\mu\text{m}$   
8.8  $10^5$  channels  
18 planes

**ACD**  
segmented  
scintillator tiles



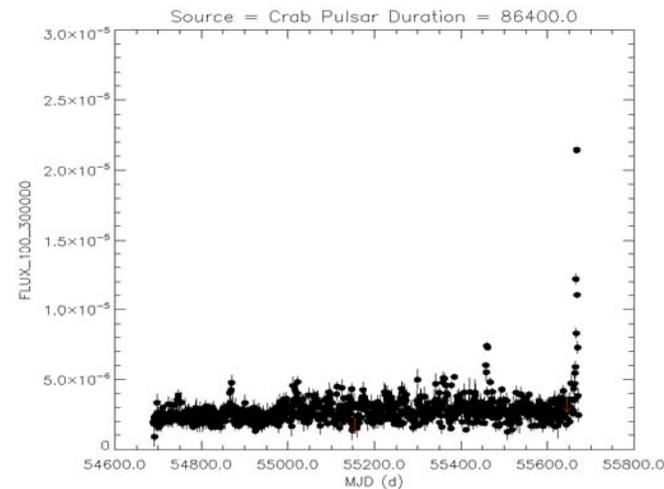
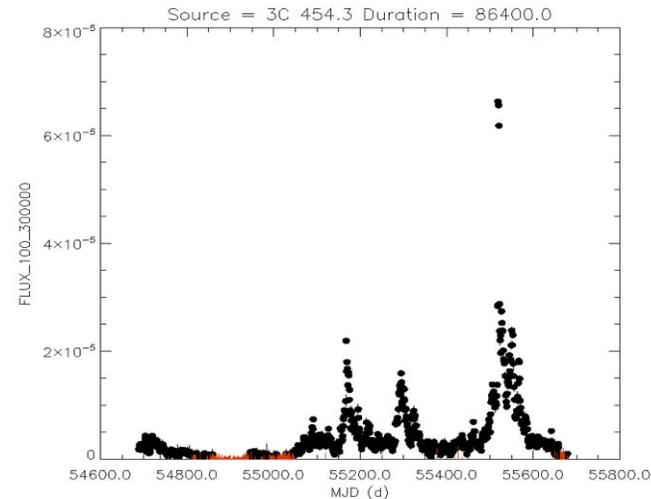
**CsI Calorimeter**  
hodoscopic array (8 layers)  
6.1  $10^3$  channels

**LAT: 4 x 4 modular array**  
3000 kg, 650 W  
20 MeV – 300 GeV

# LAT High Level Data

The LAT team releases flux/spectra as a function of time for all sources in a pre-defined list and flaring sources during flares.

- Newly active LAT sources are routinely added
  - Started with 23 sources, now have >70!



See <http://fermisky.blogspot.com> for weekly reports from LAT Flare Advocates



# LAT Data and Software Releases

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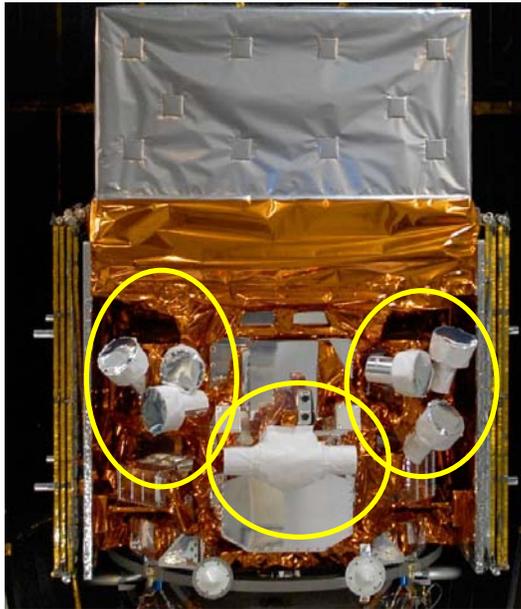
- **November 2010 - Low background event selection**
  - **Release of “DATACLEAN” event selection - provides very low background contamination for studies of diffuse emission**
- **May/June 2011 - Updated Instrument response functions**
  - **Phi dependence, rate-dependent inefficiencies and updated PSF and effective area based on in-orbit calibrations. Currently undergoing testing by FSSC. (See talk by E. Charles, poster by M. Roth et al.)**
- **May 2011 - 2nd LAT Catalog**
  - **(see talks by T. Burnett and D. Thompson later today for details)**
- **June/July 2011 - pass 7 + new diffuse model a big step forward!**
  - **Reprocessed LAT dataset with new background rejection and data quality selections. Significant performance improvements especially at low energies. (see talk by E. Charles)**
  - **Updated diffuse model with finer spatial resolution, templates for local structure, and improved extrapolation to high and low energies (see talk by J-M Casandjian later today)**

## Burst Mode Data

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- **LAT team currently developing GRB/solar flare analysis methods that use loose event selections (see talk by V. Pelassa)**
  - Provides additional effective area (i.e. more counts) especially at low energies, extending down to ~30 MeV.
  - Very high background contamination
- **Details of final event selection and reconstruction parameters not yet finalized, but it is clear that this type of event selection is useful**
  - Data volume is very high (10-30X greater than current LAT data)
  - Analysis requires instrument responses calculated with a dedicated monte carlo simulation of the GRB observation
- **Propose to make this data available for studies of GRBs and solar flares within the LAT FOV**
  - Provide data for a predefined interval around each trigger time
  - Calculate and provide instrument response matrices for the burst location and time
- **Target release date - Fall 2011/Winter 2012**

# Gamma-ray Burst Monitor



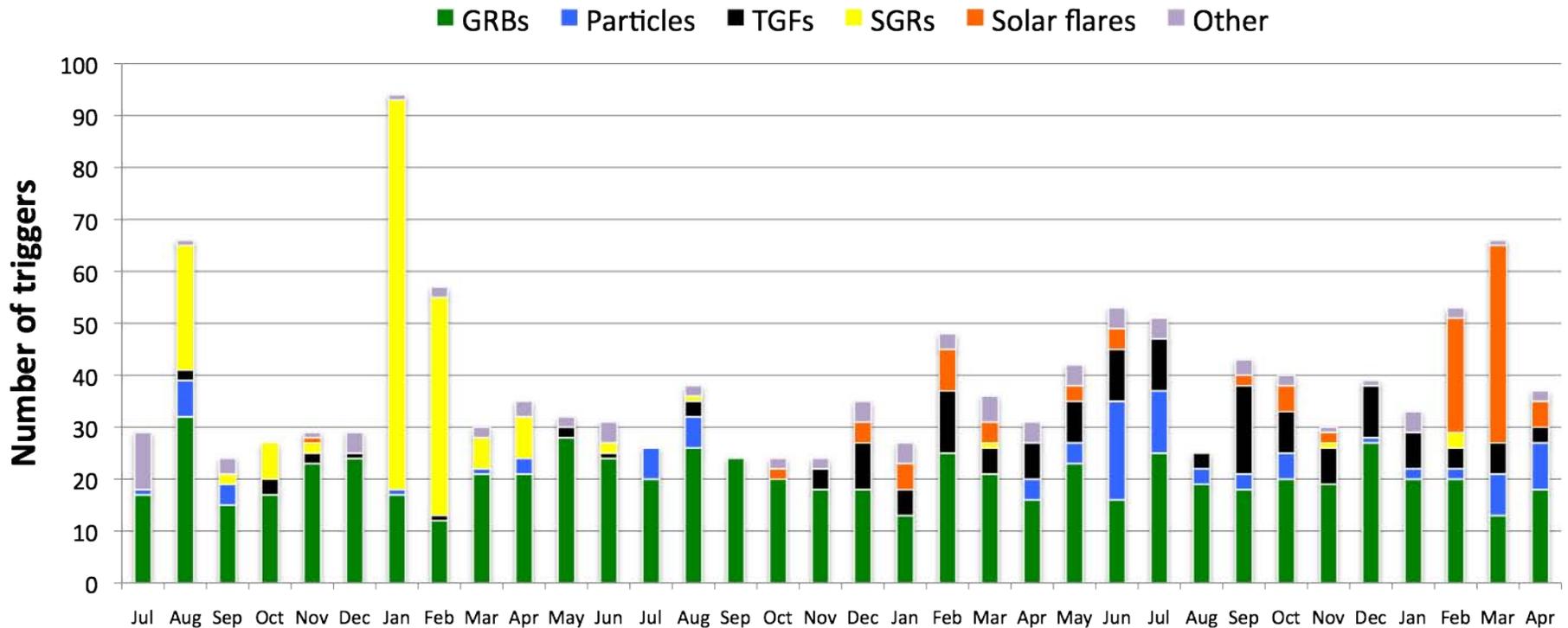
USA (MSFC, UAH, LANL) and  
Germany (MPE)

PI- Bill Paciesas (UAH)

Co-PI- Jochen Greiner (MPE)

- Since July 2008, GBM has detected over 500 GRB (250/year c.f. 200/year predicted)
  - **Benefits of flexible onboard triggering algorithms**
- Designed to detect gamma-ray transients and accreting pulsars
- Earth occultation analysis allows study of bright, hard X-ray sources
- Team also resilient to extreme Earth weather

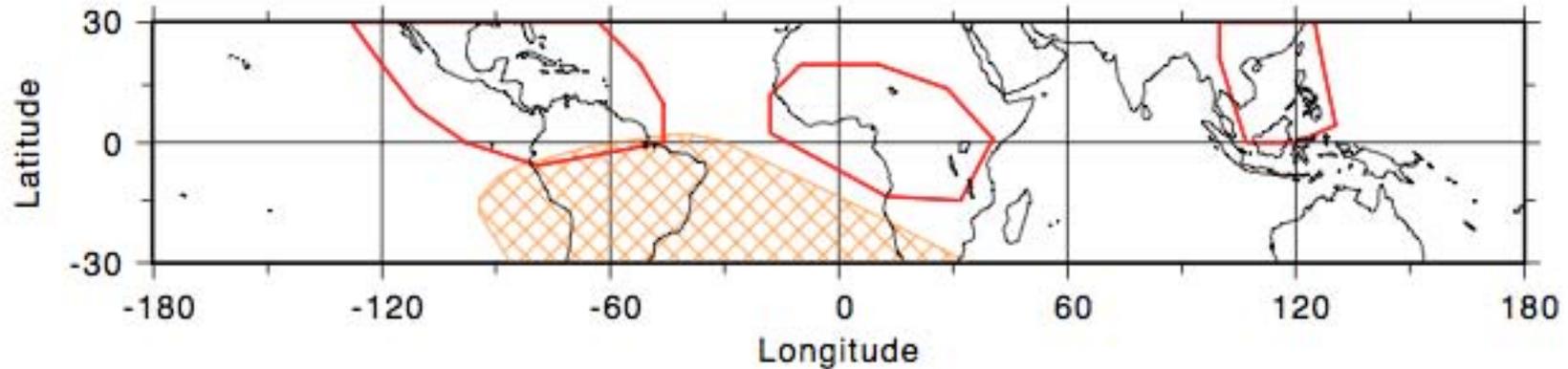
# GBM Triggers/Month



Month (starting Jul 2008)

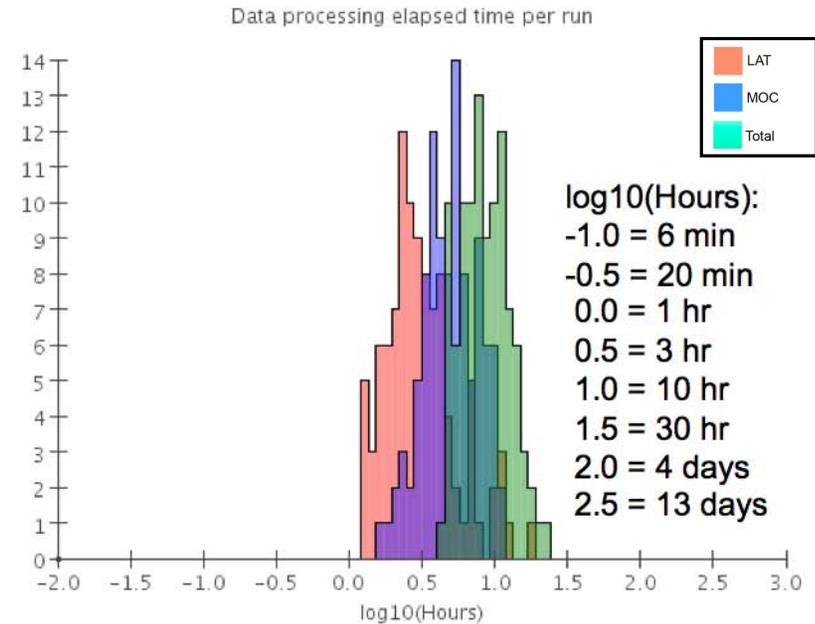
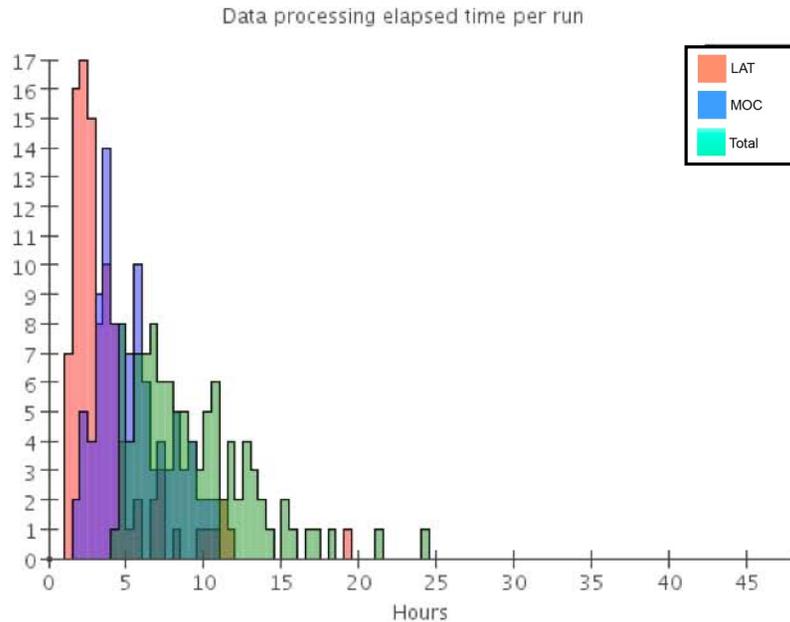
- **Nov 9, 2009 - add new TGF trigger**
  - **TGF trigger rate increased by factor of ~10 to 1 per 3.7 days (see talk by S. Foley)**
- **Feb/Mar 2011 - solar activity (see talk by Y. Tanaka)**

# Collecting Extra GBM Data over Thunderstorm Regions



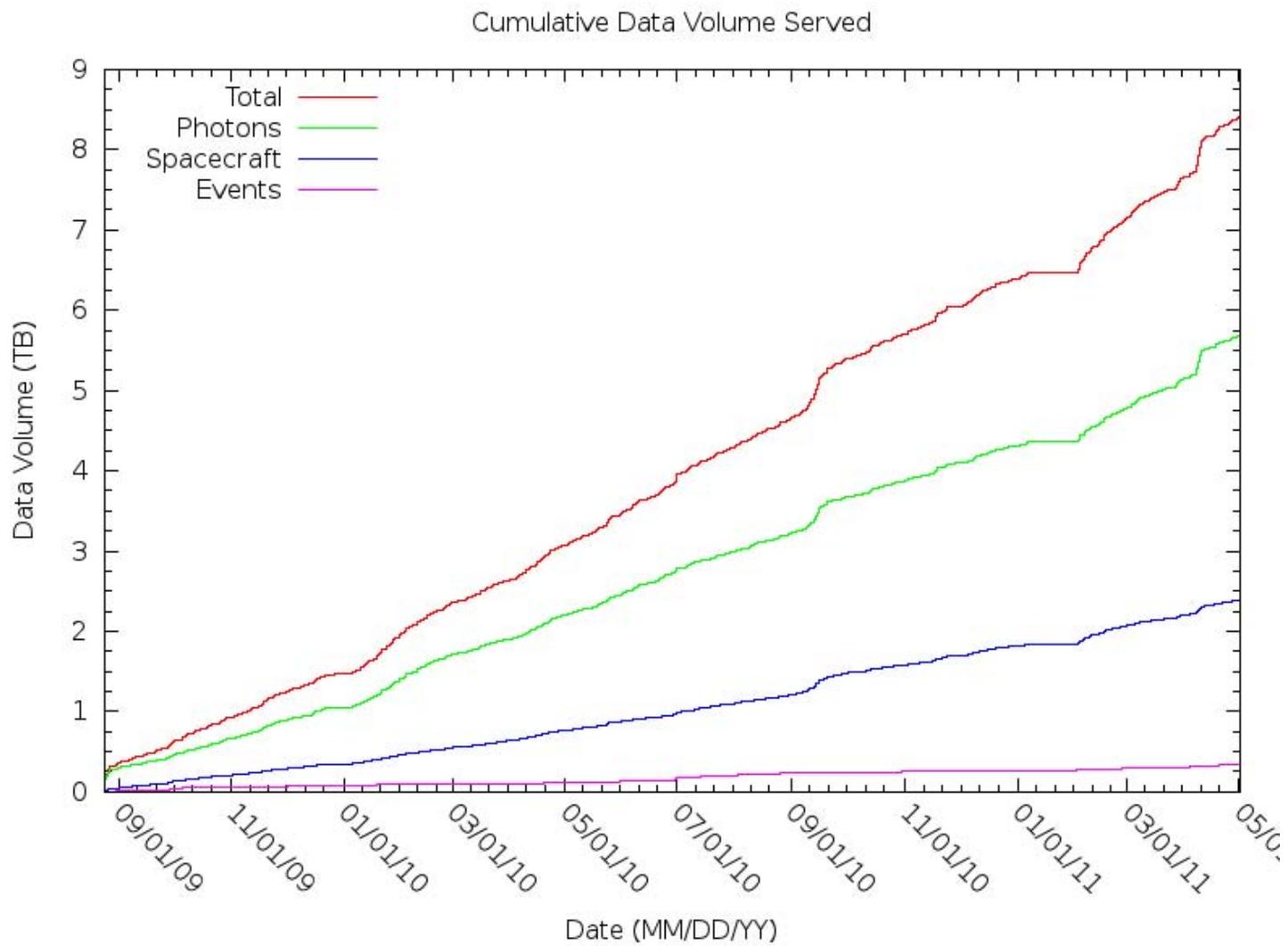
- **2010 Jul 9 to 2010 Nov 3**
  - **Americas Box #1 (148 TGFs in ground analysis)**
- **2010 Nov 4 to 2011 Mar 30:**
  - **Africa, Australia**

# Data Latency



- **LAT - Requirement of <72 hours from detection of gamma-ray photon to availability in public archive**
  - Typical latency is ~8 hours
  - **Everyone gets access to the data at the same time**
- **GBM Data is delivered to FSSC within 24 hours for routine data taking**
  - **GRBs, Solar Flares, TGFs - times, fluxes, locations delivered in near real time**

# Downloaded Data over Time





## Fermi Science Support Center (FSSC)

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- **Supports Guest Investigator program**
- **Plans observation program**
- **Hosts data and analysis software**
- **Provides documentation, workbooks, tutorials, and workshops to community**
- **Archives data to HEASARC**
- **Develops software tools with Instrument Teams and the community, utilizing HEA standards**
- **Located at Goddard**

<http://fermi.gsfc.nasa.gov/ssc/>

Help desk at <http://fermi.gsfc.nasa.gov/ssc/help/>



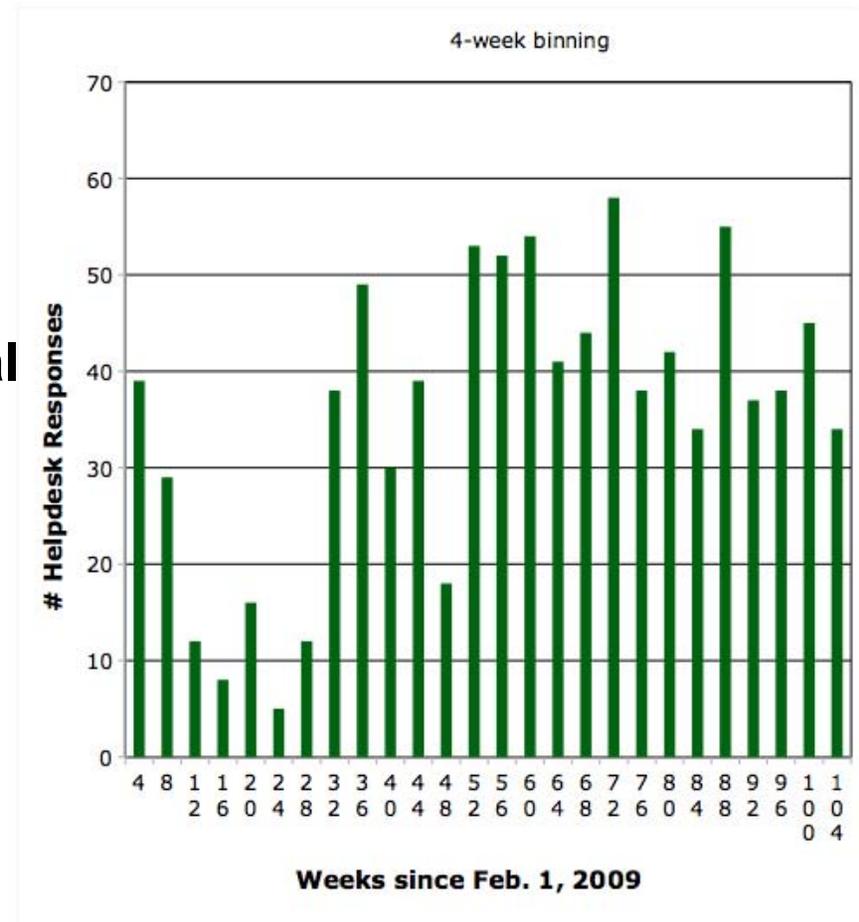
## Additional Software Releases

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- **The FSSC works to explore the feasibility of making additional tools publicly available and supported at the suggestion of the instrument teams and/or community. Examples include:**
  - **Tempo2 plugin to compute pulsar phase for LAT photons (L. Guillemot). Delivered May 2010.**
  - **Tools developed by LAT team to analyze spatially extended LAT sources (see talk by J. Lande). Currently under evaluation by FSSC.**
- **<http://fermi.gsfc.nasa.gov/ssc/data/analysis/user/>**
- **Please contact the FSSC if you have software or scripts that might be useful to the general Fermi user community**

# User Support

- The FSSC provided post-launch analysis and proposal development events in support of GI cycles 3 and 4
- Hands-on workshops Fall 2009
- Hands-on workshops + proposal and science development Fall 2010
- Presentations and tutorials available
- Help desk actively serves users





# Fermi Users Group

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- Alan Marscher (Chair)
- Matthew Baring
- Wei Cui
- Dieter Hartmann
- Jamie Holder
- Buell Januzzi
- Don Kniffen
- Savvas Koushiappas
- Scott Ransom
- Pat Slane
- Alicia Soderberg
- Anna Watts

## *Plus*

- Neil Gehrels
- Ilana Harrus
- Julie McEnery
- Bill Paciesas
- Peter Michelson
- Steve Ritz
- Chris Shrader
- Dave Thompson
- Kathy Turner
- Lynn Cominsky

<http://fermi.gsfc.nasa.gov/ssc/resources/guc/>



# Fermi GI Program

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- **Proposals to the GI program**
  - **Grants for investigators at U.S. institutions for correlated observations, analysis, theory and modeling work in support of Fermi science**
  - **Anyone can propose for observation time on Fermi or joint proposals to participating observatories!**
    - **Fermi (Pointed mode)**
    - **NOAO**
    - **NROA**
    - **Suzaku**

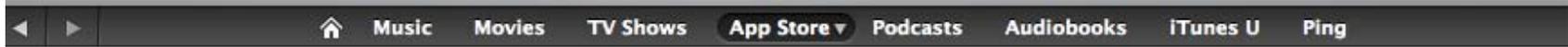
**Cycle 5 proposal deadline in January 2012**

## Fermi in Film

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- **"NASA's Fermi Catches Thunderstorms Hurling Antimatter into space"**
  - **January video views: 478,000 (70,647 NASA.gov; 75,458 YouTube; 331,885 SVS)**
- **"NASA Satellites Find High-energy Surprises in 'Constant' Crab Nebula"**
  - **January video views: 42,000 (7,020 NASA.gov; 3,200 YouTube; 31,548 SVS)**
- **"NASA's Fermi Finds Giant, Previously Unseen Structure In Our Galaxy"**
  - **November 2010 most viewed video at NASA (114,000 views in 7 days), in top 5 through January**

# Fermi the App



App Store > Education > Giacomo Saccardo



Free App

+ This app is designed for both iPhone and iPad

Category: Education  
 Released: May 05, 2011  
 Version: 1.0  
 1.0  
 Size: 11.5 MB  
 Languages: English, French, Italian  
 Seller: Giacomo Saccardo  
 © G. Saccardo & D. Bastieri 2011:  
 Padova University Press

Rated 4+

**Requirements:** Compatible with iPhone, iPod touch, and iPad. Requires iOS 3.1.3 or later

## Fermi Sky

### Description

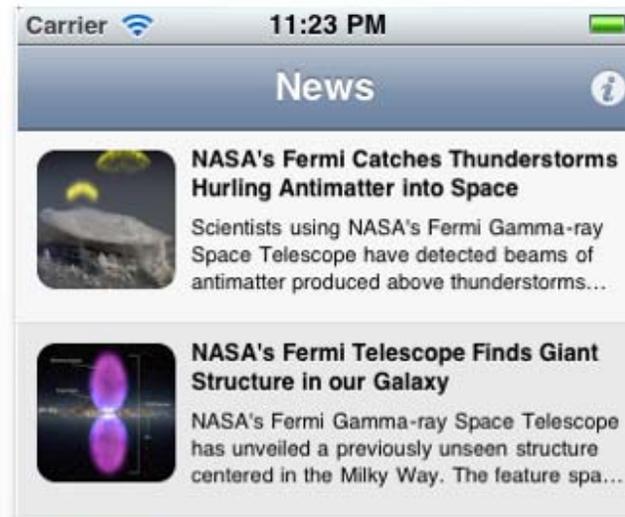
News will be available starting from 9th May, starting day of 2011 Fermi Symposium:  
[http://fermi.gsfc.nasa.gov/science/symposium/2011/...](http://fermi.gsfc.nasa.gov/science/symposium/2011/)

Fermi Sky Support >

Available on iTunes

### Screenshots

iPhone iPad





# Future Surprises

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- **We're just beginning...**
  - **Exposure continues to increase**
    - **Fainter sources become detectable**
    - **Increasingly detailed studies of bright sources**
    - **Catalogs become deeper and more detailed**
  - **Time domain studies enter longer regimes**
  - **Solar cycle beginning to warm up**
  - **Plus, efforts continue to further improve performance and enhance analysis, particularly at low and high energies**
- **The longer we look, the more surprises we will see**



# Conclusions

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- **The LAT and GBM are both working well**
- **LAT software and response updates in final FSSC testing; major data release in the near future**
- **GBM continues to detect a broad variety of MeV transients and is now benefiting from significant improvements to TGF sensitivity and increased solar activity**
- **Science and surprises from Fermi are engaging scientists and the public**
- **Fermi science easily exceeds a 4-day meeting**
- **Lots more science to come...**